IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Serial No. : 09/925,059
Applicants : Zhang, Evan
Filed : August 08, 2001
Title : IMAGE INTENSIFIER AND LWIR FUSION COMBINATION SYSTEM
Docket No. : ZZZ 033 PA
Examiner : Lee, Shun
Art Unit : 2878
Confirm No. : 2617

Commissioner for Patents
Washington, D.C. 20231

Sir:

DECLARATION TO DEMONSTRATE NONOBVIOUSNESS
OF CLAIMED INVENTION (37 C.F.R. § 1.132)

I, Evan Zhang, declare and state as follows that:

1. I am the inventor of the invention entitled IMAGE INTENSIFIER AND LWIR FUSION COMBINATION SYSTEM, disclosed and claimed in U.S. Patent Application Serial No. 09/925,059 (hereinafter the '059 application), filed August 08, 2001.

2. In a non-final Office Action dated October 16, 2006, claims 44 and 48 were rejected under 35 U.S.C. §102(b) as being anticipated by U.S. Pat. No. 5,035,472 to Hansen (hereinafter "*Hansen*"). Claims 44 and 48 were rejected under 35 U.S.C. §103(a) as being obvious in view of *Hansen*. Claims 45-47 were rejected under 35 U.S.C. §103(a) as being obvious over *Hansen* in view of U.S. Pat. No. 5,497,266 to Owen (hereinafter "*Owen*"). Claims 50-53 were rejected under 35 U.S.C. §103(a) as being obvious over *Hansen* in view of U.S. Pat. No. 6,335,526 to Horn (hereinafter "*Horn*") and claims 54-57 were rejected as being obvious over *Hansen* in view of *Owen* and *Horn*.

3. As evidence to establish non-obviousness of the claimed invention, the following are provided:

The Claimed Common Beam Splitter Configuration is Non-obvious

4. Claim 44 has been amended to further recite elements similar to that previously claimed in claim 47. Additionally, claim 47 has been canceled herein. Claim 44 now recites in pertinent part:

> ...a beam splitter arranged to receive target radiation passed through a common aperture and to split the target radiation into a first spectral band and a second spectral band which is different from the first spectral band, wherein the target radiation in the first spectral band is directed along a first optical path and the target radiation in the second spectral band is directed along a second optical path, a first objective lens in the first optical path between the beam splitter and a first sensor, wherein the first objective lens is transmissive to radiation in at least a portion of the first spectral band and a second objective lens in the second optical path between the beam splitter and a second sensor, wherein the second objective lens is transmissive to the radiation in at least a portion of the second spectral band... wherein the target radiation is not filtered by any objective lens until after being split into the first optical path and the second optical path...

In *Hansen*, all radiation passes through a common objective lens, regardless of whether that objective lens is positioned before or after a beam splitter. See for example, Objective optics 14A and corresponding beam splitter 16A in Fig. 4, and beam splitter 58 and corresponding objective 62 in Fig. 5. In *Owen*, all radiation passes through a common objective lens in each disclosed embodiment. See for example, objective lens 14 in Fig. 2, objective lens 114 in Fig. 4 and objective 214 in Fig. 6. In *Horn*, no optical systems are disclosed at all.

Thus, in each disclosed configuration of the cited art, optical parameters including the Field of View (FOV) and the focal length are fixed to the same values for each optical path by virtue of the common objective lens. In comparison, in an embodiment of my invention as claimed in claim 44, target radiation is split into two optical paths (also referred to herein as channels). A separate objective is provided for each channel. These two independent objectives can have the same FOV and focal length or different FOVs and focal lengths. Thus, for example, one channel (such as infrared) can have a large FOV for performing a quick target

search, and the other channel (such as laser) can have a narrow FOV for target identification. This structure is neither taught nor suggested from any of the cited reference.

It is very hard for a common objective lens, such as utilized in the cited references, to pass a large waveband, such as from from 0.38 to 12 μ which would be required to process VIS/NIR as well as LWIR channels as also disclosed in the cited references. Comparatively, the claimed invention recited in claim 44 comprises a common beam splitter and two independent objective lenses. Thus, a separate objective is provided for each channel.

By having a separate objective for the optical path of each channel, the F number for the objective in the MWIR or LWIR channel can have an $F \leq 1$. However, for the common objective used by the cited references, the F number would be much larger than 1. As such, the system Noise Equivalent Temperature Difference (NETD), e.g., for the MWIR or LWIR channel is much higher in the systems of the cited art compared to a system corresponding to that claimed in claim 44.

<u>Unexpected Results Differentiate the Claimed Invention From the Cited Prior Art</u>

5. The Use Of two separate objective lenses has numerous unexpected results and/or results that dramatically improve performance. As some examples, the use of a different objective lens in each optical path allows the use of conventional off-the-shelf or easily designed objectives. This simplifies designs and dramatically cuts cost.

Additionally, two independent objective lenses can have the same field of view (FOV) or different FOVs. For example, a first optical path for the LWIR sensor can have a large FOV for target searching, and a second optical path for the VIS/NIR sensor can have a narrow FOV to get a large image for target tracking and identification.

The ability to have different FOV has been recognized by others as unique and capable of solving a problem that others have failed to resolve. For proof of this, see Exhibit A, a letter

from an Associate Technical Fellow and Manager of Optical Sensor Systems for Boeing. See also, Exhibit B, a letter from the President of Defense Research Associates, Inc. In each Exhibit, an independent person has specifically identified *the claimed* common beam splitter/two separate objective configuration as "innovative" and unique.

Thus, in the claimed invention, it doesn't matter if the target is close or far, the present invention can always do real time digital pixel by pixel (same FOV) or picture in picture (different FOVs) image fusion, which the cited prior art references cannot do.

<u>*Hansen* is Inoperable as Taught</u>

6. *Hansen* discloses the use of a lens 17 to collimate radiation collected by the objective lens 14A (or 62) and to illuminate the focal plane array 18. However, this disclosed configuration cannot result in an image. In this regard, it can be observed that a collimating lens does not have the capability to focus, but rather only has the capability to illuminate, such as may be used in a conventional flashlight. Accordingly, the disclosed collimating lens 17 cannot provide an image because a collimating lens does not focus the target on the corresponding detector.

Further, in the visible channel taught in *Hansen*, the objective lens must image on a diffused screen in order for the eye piece 12A to enable a user to see the target. However, this aspect is not taught in *Hansen*. Without a diffused screen, an image cannot be obtained.

Still further, with the single objective lens taught in *Hansen*, the waveband from visible to far infrared is very wide (0.38 to 12 microns). It is currently very difficult, and likely impossible, to make the required broad band objective lens, and to correct the aberrations, especially the color aberration by the objective lens alone. However, there are no aberration correction lenses taught or suggested in the system disclosed by *Hansen*. As such, it is unlikely that a reasonably good image can be achieved. Moreover, the use of germanium as taught in *Hansen* for the beam splitter is impractical because this particular beam splitter arrangement

achieves approximately 40% transmission, which makes it difficult to produce a reasonable image.

The Claimed Combination of Optical and Electronic Fusions is Non-obvious

7. Claim 52 recites in pertinent part:

> ...a first sensor arranged to receive radiation in a first spectral band and provide a first image of the radiation filtered into the first spectral band, a first optical output derived from the first image and a first electronic output derived from the first image;
> ...a second sensor arranged to receive radiation in a second spectral band and provide a second image of the radiation filtered into the second spectral band, a second optical output derived from the second image and a second electronic output derived from the second image;
> ...a beam combining device arranged to optically fuse the first optical output and the second optical output into a third optical output;
> ...a viewer for viewing at least one of the first optical output, the second optical output or the third optical output;
> ... a processor arranged to electronically fuse or combine the first electronic output and the second electronic output into a third electronic output; and
> ... a display device arranged to selectively display at least one of the first electronic output, the second electronic output or the third electronic output ...

Optical fusion can not only preserve the relatively high resolution of sensors in two or more separate channels, but also can use the eye to directly observe the fused image from two sensors. Electronic fusion cannot use the eye to directly observe the fused image. For example if the VIS/NIR sensor is an image intensified tube with a resolution of 72 line pairs per millimeter and if we use CCD to digitize its image, the resolution will be reduced to half.

However, optical fusion cannot do pixel by pixel fusion and feed to a computer for image processing and wireless communication, which can be accomplished with electronic fusion. Thus, the *claimed* approach provides the simultaneous optical and electronic fusion that can take the advantages and overcome the shortcomings of both individual fusions. No references have been cited that show prior to the claimed invention, a system that combined both electronic

sensor fusion and optical sensor fusion. It is believed that those skilled in the art did not realize the importance of simultaneous fusion, or selected either optical fusion or electronic fusion specifically to suit a particular application, as is apparently the case in each of the cited references.

8. Moreover, I have claimed in dependent claim 56, a common beam splitter approach which is discussed in greater detail above. In my embodiment that *does use* a common objective lens as claimed in claim 54, I also claim the use of relay lenses in the different channels to correct the aberrations in their corresponding bands. In this regard, not only are there enough optical materials available for the LWIR band (8 – 12 microns) and VIS band (0.38 – 0.76 microns) but it is also relatively easy to correct aberrations, where the required corrections are limited to these narrower bands. *Hansen* and *Horn* do not teach this.

Owen discloses correcting for astigmatism and flattening of the visual field. However, *Owen* does not teach a sensor fusion system as claimed (electronic or optical) as only one sensor is taught. Moreover, the correction is only taught with regard to correction of the image provided to the image intensifier tube. Thus, that which I claim is neither taught nor suggested by the cited references.

As a person signing below:

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code, and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

Full name of inventor: Evan Zhang, Ph.D.

Inventor's signature: ____________

Date: January 8, 2007

Country of Citizenship: USA

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EXHIBIT A

The Boeing Company
P.O. Box 3707
Seattle, WA 98124-2207

BOEING

October 10, 2006

Boeing Phantom Works –
Optical Sensor Systems

Dear MDA SBIR Program Manager:

The Principal Investigator Dr. Evan Zhang of Zybron Optical Electronics, Inc. has submitted a very innovative proposal "Active and Passive EO/IR Sensor Fusion" to your SBIR topic MDA06-013. Boeing Phantom Works actively supports Boeing's role as a lead system integrator in MDA system investments, and is chartered to identify and pursue enabling new technologies to support MDA objectives. Boeing recognizes the goals of this SBIR topic, and Dr. Zhang's offering, as addressing key integration and performance issues for sensing payloads with critical missions.

The proposed effort provides a very attractive approach for developing a fusion system with a very wide FOV for IR sensor to quickly search the target and a very narrow FOV for EO sensor (such as a Ladar) to quickly discriminate the target. Although common optical refractive or reflective lenses have no parallax, they have seriously limited field of views. In Dr Zhang's proposal an innovative common optical aperture beam splitter is proposed. It not only can eliminate the parallax between the IR and EO sensors but also can let the IR head have a very large FOV and the gated Ladar have a very small FOV to see the same target through cloud, fog, rain, camouflage and darkness. In addition, a very innovative stand-alone real-time digital pixel-by-pixel sensor fusion board will also be designed to precisely overlay two images. This board will be able to execute detection, ranging, tracking and identification of the target, and perform digital image processing for target recognition.

Clearly, this technology has exciting promise for important military and commercial applications. Boeing is very interested to team up with Zybron for this Phase-I effort, and in playing a major role in the following phases of development, production, and deployment. If you have any questions please call me at 425-965-1390.

Sincerely,

Jonathan Saint Clair, Ph.D.
Associate Technical Fellow
Mgr. (A) Optical Sensor Systems
Boeing Phantom Works
Seattle, Washington
Jonathan.m.saintclair@boeing.com
425-965-1390

EXHIBIT B

DRA
Defense Research Associates, Inc.

October 9, 2006

Subject. SBIR topic MDA06-013

To Whom It May Concern.

Dr. Evan Zhang, the Principal Investigator of Zybron Optical Electronics, Inc. has submitted what we consider a very innovative proposal for "Active and Passive EO/IR Sensor Fusion" to your SBIR topic MDA06-013. Unlike a common optical refractive or reflective lens that has a narrow field of view (FOV), his proposed common beam splitter allows the IR sensor to have a very wide FOV to quickly search the target and the EO sensor (such as a gated laser Radar) have a very narrow FOV to quickly discriminate the target. Since the narrow FOV is inside the wide FOV, the two heads have no parallax. A small real time digital pixel by pixel sensor fusion board is also proposed. This fusion board precisely overlays the active (or passive) EO image on the passive IR image so that digital image processing and automatic target recognition can be performed. We believe this technology will not only be useful for the effective missile launch detection, ranging, tracking and identification but also for many other military and commercial applications. For example, a helmet mounted EO/IR sensor fusion system could replace the night vision goggles and IR imagers currently in use. Defense Research Associates, Inc is very interested in to teaming with Zybron for this Phase-I effort and will help Zybron to produce the prototype in Phase-II and to ultimately take the technology to production in Phase-III.

If you have any questions please don't hesitate to contact me at 937-431-1644.

Sincerely,

President
Defense Research Associates, Inc.